Original Research

Technology-Mediated Therapy for Chronic Pain Management: The Challenges of Adapting Behavior Change Interventions for Delivery with Pervasive Communication Technology

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Abstract

Objective: *Adapting therapeutic practice from traditional face-to-face exchange to remote technology-based delivery presents challenges for the therapist, patient, and technical writer. This article documents the process of therapy adaptation and the resultant specification for the SMART2 project—a technology-based self-management system for assisting long-term health conditions, including chronic pain.* ***Materials and Methods:*** *Focus group discussions with healthcare professionals and patients were conducted to inform selection of therapeutic objectives and appropriate technology.* ***Results:*** *Pertinent challenges are identified, relating to (1) reduction and definition of therapeutic objectives, and (2) how to approach adaptation of therapy to a form suited to technology delivery. The requirement of the system to provide dynamic and intelligent responses to patient experience and behavior is also emphasized.* ***Conclusion:*** *Solutions to these challenges are described in the context of the SMART2 technology-based intervention. More explicit discussion and documentation of therapy adaptation to technology-based delivery within the literature is encouraged.*

Key words: *chronic pain, self-management, telecare, electronic therapy, e-therapy*

Introduction

Postindustrial societies face unprecedented healthcare challenges. Chief among them is how to find sustainable health management solutions to the growing number of people aged 65 and older who are living with one or more long-term health conditions. Modern communication technologies offer significant opportunities for increased access to consultation and potentially to deliver assistive therapy to those living with long-term health conditions.

Exploitation of communication technologies for healthcare delivery (telehealth) is promoted as a potential method of redefining healthcare and its capacity to meet these new demands.[1] The overarching aim of telehealth is to capitalize on the benefits technology may afford to the healthcare system in terms of economic development, access to treatment, and improved patient outcomes. Research directed toward uniting the capacity of modern technologies with healthcare has grown considerably in recent years.[2] Within the treatment of pain alone, current applications of technology range from in-clinic facilitators such as electronic patient diaries[3] and therapeutic virtual-reality simulation,[4–6] to delivery of in-home monitoring[7] and therapy.[8–10]

The SMART2 project (www.thesmartconsortium.org) is concerned with developing effective self-management for long-term health conditions, including chronic pain.[11] A systematic review of telehealth interventions for long-term health conditions undertaken as part of the SMART2 project illustrated two pertinent issues: (1) therapy underpinning interventions is often ill-described, with no report of methods of therapy conversion from traditional to technological delivery, and (2) attrition rates for self-management are often high, but may be reduced by even minimal human contact.[12] There is overwhelming evidence that more consideration needs to be given to the adaptation of therapy rather than direct translation,[13] given that the delivery methods between traditional and technological intervention are not equivalent. There are notable differences in the way an individual interacts with other individuals in comparison with machines and with other individuals through machines.[14,15] Ritterband et al.[13] suggested a model of intervention for behavior change, emphasizing interaction components, including, but not limited to, appearance, content, engagement, and burden of use. Although this model is intended for Internet-based delivery, many of the assertions are potentially transferable to other communication technologies.

In addition, a critical feature of the successful therapeutic relationship is therapist flexibility—that is, the therapist's ability to respond to the patient's present experience and behavior.[16] A significant contributor to a technology-based intervention's sophistication lies in its ability to synthesize this therapeutic interchange, providing intelligent and dynamic responses based on current behavior and experience. A technology-based intervention must, therefore, account for both human–computer interaction and the dynamic experience of the patient if it is to provide appropriate therapeutic value.

DOI: 10.1089/tmj.2010.0136

At present the process of adapting traditional therapy for technology delivery has not received adequate attention; telehealth interventions often provide unclear report as to methodology and outcome of this challenging process.[12] In this article we outline the route taken through the SMART2 project toward meeting this challenge, documenting the development of the chronic pain component of the self-management intervention through the methodology and solutions employed to tackle the challenges of (1) simplifying therapeutic goals to those relating to a specific behavior, so that the intervention can be effectively evaluated in a clinical trial, and (2) adapting traditional therapeutic objectives to a technology-based system. We seek to promote explicit discussion and documentation within the research community as to how therapy can be most effectively adapted for technology.

Materials and Methods

Determining therapeutic and technology components of the intervention required the collective input of therapeutic knowledge and practice from specialist clinicians, and the experiential knowledge and technological preferences of patients experiencing chronic pain. Reviews of determinants of assistive technology use have repeatedly emphasized the need to simultaneously consider user expectations, technology matching, and intervention content.[17,18] Accordingly, focus groups were held with healthcare professionals (HCP) and chronic pain patients. The HCP group consisted of a mix of clinical psychologists, occupational psychologists, physiotherapists, and nurses ($n = 12$) working at the Royal National Hospital for Rheumatic Diseases (RNHRD) NHS Trust, Bath. Two focus groups were held with patients ($n = 6$) and four patients were interviewed in their homes. All focus groups were semistructured, and audio and/or visual recorded.[19] Patients were recruited from the local primary care trust and/or previous patients from the RNHRD pain management service. The output of the focus group discussions were examined and reflected upon by the SMART2 consortium and employed to inform therapy content and technology selection detailed subsequently.

Results and Discussion

THERAPEUTIC OBJECTIVES AND PATIENT PREFERENCES

The first stage of development was to determine the key therapeutic objectives of the intervention to be incorporated into the technological device. Many previous telehealth interventions have been either too simplistic and thus of questionable therapeutic value, or overly complex and consequently difficult to interpret and evaluate.[12] In contrast, the SMART2 project focused on targeting a specific type of behavior known to be of broad therapeutic and personal value to individuals experiencing chronic pain. We considered that this approach would provide more clarity when evaluating active therapeutic agents in a subsequent clinic trial.

The target behavior of walking-based movement was selected as it is necessary for the successful execution of a wide selection of personal activities. Based on the HCP focus group input, the therapeutic objective of SMART2 for pain management targets the common occurrence of maladaptive cycles of behavior that exacerbate distress and restrict the individual's ability to regularly participate in meaningful activity.[20]

Maladaptive cycles of activity and activity pacing. Pain is a disruptive experience. The natural response to pain is to avoid actions that increase pain. In the case of chronic pain this avoidance can lead to substantial periods of inactivity when pain is particularly bad, and compensation for this inactivity through periods of over activity when pain subsides. Over activity, however, frequently results in a subsequent increased experience of pain, which restarts the cycle.[21]

The cycle of activity described has a disruptive impact on the individual's everyday life and ability to regularly participate in activities and events that are personally important. Therefore, an aim of therapy is to assist the individual to both manage and pace their activity. Patients are encouraged to experiment with planning their behavior time contingently rather than pain contingently, thus breaking the cycle and allowing for more consistent activity. This is a difficult balance to achieve as it requires the individual to maintain a certain level of activity while experiencing pain and limit their activity when pain subsides, both of which can seem counterintuitive. To facilitate more adaptive consistent activity, the SMART2 intervention must encompass features that increase the individual's awareness of their own patterns of behavior and psychological experience, as well as assisting the user in the pursuit of personal goals.

Therapeutic content and presentation. To facilitate the behavior change required to manage activity two main intervention components were deemed necessary. First, the intervention must facilitate the pursuit of value-based goals particular to the individual user. Value-based action is considered critical to therapeutic outcome, as participation in activity that is not personally meaningful is unlikely to be relevant or salient to the individual and consequently will be unsustainable. Further, both physical functioning and mental well-being have demonstrated relations with successful involvement in valued domains.[22] Second, therapeutic feedback must facilitate mindfulness of and reflection on activity, rather than providing proscriptive advice. Accordingly, all text-based feedback was determined to provide reflective comments relating to progress toward goals (e.g., "Notice whether you are currently pursuing a goal you set out to pursue and, if you are, notice that this is already a kind of success"), goal achievement (e.g., "It seems you have met your goal. Take a minute to consider your personal values that are being served by you doing this"), and activity quality (e.g., "Check in with yourself for a moment. Are you as at ease as you could be? Is the speed or intensity you are using appropriate for what you are doing? Notice your ability to choose how you do things").

The outlined feedback was designed to raise awareness in the user of their patterns of behavior and psychological experience across all time frames—that is, in real-time, retrospective review, and in planning future activity. Additionally, the intervention content and feedback must be tailored so that it is appropriate at any given moment. Personalization of content and system response must be dynamic and informed by both the patient's current behavior (e.g., goal progress and activity pattern) and experience (e.g., affective state), as current state of mind may influence interpretation of information.[23] To achieve these aims it was necessary to identify a selection of key activity variables forming the parameters of therapeutic response for incorporation into the SMART2 intervention. The key variables were the amount of movement-based activity, location, participation in goal activity, quality of activity, and patient experience of pain intensity and their affective state. The next stage of development required determining the acquisition and interpretation of these data within the context of the therapeutic aims outlined.

ADAPTING THERAPEUTIC OBJECTIVES TO A TECHNOLOGY-BASED SYSTEM

Adaptation of the therapeutic objectives involves not only the conversion of therapy to technology-based delivery, but also the selection of technology with the capacity to deliver and facilitate these objectives. Patient preferences, determined from the focus groups, emphasized discrete, nonintrusive technology that can be customized to personal goals. Correspondingly, the intervention consists of familiar computing and mobile technology, delivering therapeutic strategies to assist the user in achieving personalized goal objectives.

Personalizing goals and system parameters. To populate the SMART2 system with individual specific goals, a face-to-face session between the intended user and therapist is required before installation. The goal-setting component of intervention customization is a complex therapeutic task[24] and not realistically a process that could be automated within this project. It was decided, therefore, that the system configuration (i.e., goal and activity parameter determination) would be conducted in a traditional consultation between therapist and patient. This methodology was considered the most ethically responsible approach to ensure appropriate parameter and goal selection. Finally, for the purposes of the present project, goals have been limited to those that can be quantifiable in terms of movement-based activities.

Therapist-led discussion is employed to first establish values. Value identification then drives the selection of general life goals, which are then broken into achievable and measurable component subgoals.[25] In this case the focus is on component subgoals that require physical activity as part of their accomplishment. *Table 1* gives an example in which an overall value identified by a prototypical patient as "being independent" leads to a series of general life goals such as "buying my own newspaper form a store rather than having it delivered," which can be broken down into component subgoals necessary to achieve the task (e.g., walking for 300 m, standing in line for 2 min, etc.). The identification of all component subgoals allows for planning, and pacing of activity within the SMART2 system.

Realistic parameters for frequency of activity completion and boundaries of over- and underactivity are assessed and determined by the therapist. Additionally, patient-rated difficulty for each activity is inputted using on a scale from 1 to 5. The resulting information populates the SMART2 intervention with the individual's personalized goals, activities, and parameters for physical activity.

The SMART2 system. The technological components of the system were selected to fulfill the therapeutic objectives and patient preferences outlined in the focus groups, thus meeting the following criteria:

1. familiar, for ease of use;
2. discreet, for ease of integration and to avoid unnecessary attention;
3. multifunctional, to be economical in terms of space and setup; and
4. mobile, for real-time monitoring and response.

To provide both detailed and real-time feedback, the SMART2 system incorporates two modes of intervention delivery. A decision support system (DSS) interprets patterns of activity based on the personalized parameters, and provides an appropriate therapeutic response.[11] The DSS also incorporates a mood-congruent response.

Table 1. Patient-Identified Values and Life Goal, and Negotiated Subgoals Worked Out with Therapist

VALUE	LIFE GOAL	SUBGOAL
1. Being independent	1. Visit store in person to buy my daily newspaper instead of having it delivered	1. Identify best time
2. Being more social		2. Wear appropriate clothing put on outdoor shoes, coats, etc.
		3. Secure house
		4. Walk 300 m to store
		5. Stand in line for anything between 1 and 6 min
		6. Talk to storeowner

There is no limit on the number of values or life goals that can be generated. Similarly, many life goals can be relevant to a number of values. In this example, our prototypical pain patient has identified an independence and a social inclusion value. In identifying a visit to the store this can meet both values.

Self-report assessments of mood and other experiential variables throughout the day are used to inform the presentation and phrasing of therapeutic content. Thus, when an individual reports poor mood they receive different therapeutic encouragement than when reporting good mood, although in both instances the underlying message remains the same. Therefore, the SMART2 intervention provides the basis for feedback responsive to both behavior and how the individual feels. The architecture of the SMART2 system relating technological components with monitored behavior, experiential variables, and the intervention response is outlined in *Figure 1*.

Mobile device. A HTC (model HD2) smartphone was selected for real-time monitoring and feedback of behavior. The smartphone is navigated through touch-screen technology and utilizes an inbuilt accelerometer and Global Positioning System (GPS) technology to cooperatively monitor the individual's physical activity. Self-report items on experiential variables such as pain intensity and mood (rated 0–9) are also collected through a graphical user interface on the smartphone. Feedback on activity progress, determined by the DSS, is presented in the form of pictorial progress charts and short message service text message alerts. Alert messages are triggered in real-time based on

1. patient location (i.e., GPS monitored hotspot locations relating to activities),
2. progress achievement (i.e., completing an activity), and
3. behavioral parameters (i.e., over activity and inactivity).

The smartphone is the sole peripheral monitoring device and is able to provide a range of monitored variables for feedback. The phone communicates with a static touch-screen computer situated in the patient's home using wireless local area network technology. Data are synchronized when the smartphone is within network signal range; otherwise, any data are stored locally on the Smartphone; data collected by the Smartphone automatically update the static computer, which then provides more detailed feedback on progress and activity management.

HomeHub. The mobility of the smartphone enables discrete measurement and real-time response on activity. Practical restrictions such as screen size, however, limit the amount and detail of progress that can be provided. To allow for daily activity planning, elaborated feedback, and daily review of progress, a static touch-screen computer (HomeHub) is the second component of intervention delivery. The HomeHub is an eeeTop manufactured by Asus. The interface provides the patient with the SMART2 system content, which includes

1. Summary of personalized goals and related activities
2. Daily activity plan
3. Progress feedback
   a. General movement
   b. Specific activity
   c. Map of travel
4. Daily activity review

The SMART2 software for the HomeHub is designed to assist with activity planning and reflection on progress. Through the interface the individual may review their current progress personalized goals and activities. In addition, he/she will utilize the interface on a daily basis to determine a realistic plan of activity for the day. The DSS includes a self-identified difficulty rating for activities and feedback on previous progress to advise incremental increase in paced activity. All therapeutic content within the intervention is nonprescriptive and serves only as an aid for decision making. Ultimately, the patient determines their own daily plan.

The progress feedback screens will provide detailed graphical representation of movement and patient experience across time, on both gross activity dimensions (i.e., daily/weekly movement) and specific activity (i.e., relating to participation and completion of a set goal activity). Therapeutic text and advice dependent on progress and most recent self-reported mood accompanies the pictorial display. Therapeutic text serves to encourage and assist progress toward paced activity.

The daily activity review section provides another therapeutic component, encouraging daily reflection on progress, achievement, and obstacles. Patients complete text responses to guided therapeutic questions about their progress, which has been designed to facilitate reflective thought and directed expressive writing.[26]

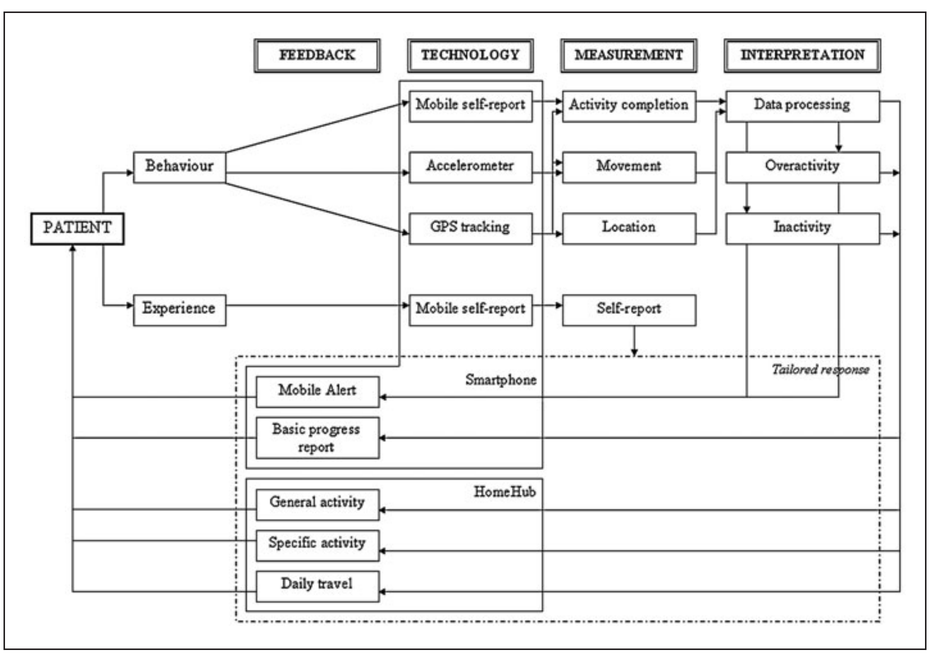

Fig. 1. SMART2 system architecture for chronic pain intervention.

Conclusions

In this article we have detailed a process undertaken for the SMART2 intervention of adapting traditional therapy to technology delivery. The challenges of focusing therapy strategies, presentation, and objectives for telehealth interventions have been emphasized, along with the complexity of simulating critical features of the patient–therapist relationship. Our work is not intended to provide conclusive template or manual for therapy adaptation, but instead is designed to stress the need for consideration and innovation in how therapeutic content is delivered without a therapist, and what form that content should take.

Development of the SMART2 system[27] has been driven by a user needs-pull approach rather than technology-push. The knowledge and experience of both clinicians and patients has informed development of the technology-based intervention rather than fitting those needs to predetermined technology. The system utilizes pervasive technologies to facilitate ease of use and minimize disruption. By separating the intervention into two main components, the SMART2 system will be able to provide mobile real-time response as well as detailed activity management and review. This intervention unites features of flexibility and personalization to form an intelligent system for the self-management of long-term health conditions. This article has focused on the system's approach to chronic pain management. Development of the framework has prioritized the importance of tailoring both therapy and technology to the patient to encourage sustained use.[17,18] The research is part of a new wave of user-centered, technology-based healthcare designed to provide sustainable long-term treatment and empowerment for the increasing number of individuals experiencing such conditions.

Adaptation of therapy for technology delivery has required simplification of intervention objectives to a set of core behavioral targets aimed at extinguishing cycles of maladaptive behavior. In response to a frequent lack of clarity in evaluating individual therapy components contribution to technology-based intervention efficacy,[12] the reduced and defined therapeutic strategy affords a more effective evaluation of the active therapeutic agents of the SMART2 intervention in the future clinical trial.

Therapeutic goals and activities have been quantified based on specific attributes such as location monitoring, movement, and self-report experience. These quantifiable attributes were employed as parameters for the system so that it is able to appropriately interpret and respond dynamically to patient behavior and experience. Personalization of the system was emphasized through system calibration to the individual and their environment, subjective value-based goals/activities, and mood dependent feedback. The flexibility of feedback and the reflective nature of its content has been designed to synthesize elements of traditional patient–therapist interaction and avoid prescriptive instruction. The next stage of development will involve prototype testing of the intervention within the home. The SMART2 intervention will be personalized to each user, and its capacity to facilitate self-management, activity pacing, and quality of life will be assessed.

The need for new healthcare solutions is a current significant challenge and one anticipated to escalate. Treatment of long-term health conditions accounts for a substantial portion of healthcare expenditure[28] with recent estimates suggesting that this figure has reached 70% of gross healthcare spending.[29] Modern developments in technology provide the means to unite the benefits of resource accessibility and mobility with healthcare. Development of a framework for the SMART2 system illustrates the complexity in adapting even a small component of traditional therapy to a technology-based intervention and the distance still left to travel in truly optimizing telehealth interventions. The current healthcare model is unsustainable; technology may provide a portion of the solution. There remains, however, substantial work if telehealth is to fulfill the promises made and revolutionize healthcare. Key to this revolution is the incorporation is sustainable health-related behavior change that requires therapeutic support. If we are to re-conceptualize where and how treatment can be optimally received, we must enter into more discussion and research of how therapy might be adapted to promote behavior change through technology delivery.

Acknowledgments

The SMART2 consortium (www.thesmartconsortium.org) is a collaboration of the Universities of Bath, Ulster, Sheffield, and Sheffield-Hallam. This research is supported by a grant from the Engineering and Physical Sciences Research Council, United Kingdom (EP/F001916).

Disclosure Statement

No competing financial interests exist.

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Received: August 13, 2010
Revised: September 28, 2010
Accepted: October 1, 2010